NAVAL WAR COLLEGE
Newport, R.I.

Doctrine is the True Center of Gravity for Force Transformation

by

Jonathan C. Wright
Lieutenant Colonel, USAF

A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

Signature: ______________________________

13 May 2002

REPORT DOCUMENTATION PAGE

1. Report Security Classification: UNCLASSIFIED	
2. Security Classification Authority:	
3. Declassification/Downgrading Schedule:	
4. Distribution/Availability of Report: DISTRIBUTION STATEMENT A: APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED.	
5. Name of Performing Organization: JOINT MILITARY OPERATIONS DEPARTMENT	
6. Office Symbol: C	**7. Address**: NAVAL WAR COLLEGE 686 CUSHING ROAD NEWPORT, RI 02841-1207
8. Title (Include Security Classification): Doctrine is the True Center of Gravity for Force Transformation (UNCLASSIFIED)	
9. Personal Authors: Lieutenant Colonel Jonathan C. Wright, USAF	
10.Type of Report: FINAL	**11. Date of Report**: 13 MAY 2002
12.Page Count: 17 **12A Paper Advisor (if any): Professors FitzSimonds & Mahnken**	
13.Supplementary Notation: A paper submitted to the Faculty of the NWC in partial satisfaction of the requirements of the JMO Department. The contents of this paper reflect my own personal views and are not necessarily endorsed by the NWC or the Department of the Navy.	

14. Ten key words that relate to your paper:

Doctrine, force structure, transformation, aircraft carrier, systems, evaluation, development, lessons learned

15.Abstract:

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This paper asserts that doctrine is the center of gravity for force transformation. It looks at the Japanese, British, and American experience developing aircraft carriers between WW I and WW II. The technical, fiscal, and political environment in which the development occurred is analyzed and key themes from the each nation's development practices are identified as well as how these themes influenced relative success or failure in the development. The paper then shows that today's development environment is highly similar. The key themes from aircraft carrier development are doctrine based (vice technology based) and are extrapolated to form suggestions for how today's leaders may best focus efforts to successfully transform the military force.

16.Distribution / Availability of Abstract:	Unclassified	Same As Rpt	DTIC Users
	X		

17.Abstract Security Classification: UNCLASSIFIED	
18.Name of Responsible Individual: CHAIRMAN, JOINT MILITARY OPERATIONS DEPARTMENT	
19.Telephone: 841-6461	**20.Office Symbol:** **C**

Security Classification of This Page Unclassified

Abstract of

DOCTRINE IS THE TRUE CENTER OF GRAVITY FOR FORCE TRANSFORMATION

Transformation is a much-used term in operational literature and the popular press. However, it is usually discussed in terms of systems (e.g. F-22, Crusader, DD-21). Little attention or press is given to doctrine and transformation.

This paper asserts that doctrine is the center of gravity for force transformation. It looks at the Japanese, British, and American experience developing aircraft carriers between WW I and WW II. The technical, fiscal, and political environment in which the development occurred is analyzed and key themes from the each nation's development practices are identified as well as how these themes influenced relative success or failure in the development. The paper then shows that today's development environment is highly similar. The key themes from aircraft carrier development are doctrine based (vice technology based) and are extrapolated to form suggestions for how today's leaders may best focus efforts to successfully transform the military force.

An electronics and information revolution has permeated modern society since the introduction of the transistor and the Internet and has also impacted the nation's military forces. There is an ongoing debate about whether this impact constitutes a Revolution in Military Affairs (RMA). Undebated is that this revolution has enabled the United States military to achieve both greater precision in munitions and that computers and information technologies permeate today's military systems[1]. This revolution has also unlocked the door to other advanced technologies such as stealth (e.g. low signature) systems.

The military is in the process of replacing weapon systems purchased in the 1980's (e.g. F-15 aircraft); weapon systems largely based on 1970's designs and technologies. This opened a discussion on force transformation: "These days, just about every service and defense contractor boasts that its weapon system is 'transformational', the new buzz word of the Bush Pentagon."[2]

The emphasis on transformation is overwhelming. "'Everything is being called transformational', says Loren B. Thompson, chief operating officer of the Lexington Institute, a nonpartisan defense think tank. 'It has almost completely lost its meaning.'"[3] Weapon systems as diverse as the Air Force's F-22 fighter and the Army's Crusader artillery system are touted as transformational[4]. Missing from the discussion of what constitutes force transformation are questions of "Can transformation be achieved through a focus on weapon systems?" and "What role do doctrine and operational concepts and force employment play in transformation?"

This paper will explore the development of the aircraft carrier and carrier aviation doctrine in the interwar period, between WW I and WW II, to show the key role doctrine played in the transformation of naval power from fleets centered around battleships and their

guns to ones centered around aircraft carriers and their aircraft. This transformation did not occur simply due to exploitation of new technologies; doctrine and technology worked together to achieve real transformation. Nations developing naval aviation had access to relatively the same technologies and had to deal with the same operational issues. Their success or failure hinged on the application of doctrine to frame operational issues and then shape the technological answers to those operational issues. This justifies this paper's thesis: doctrine is the center of gravity[5] of force transformation. This historical example will then be used to outline recommendations for how doctrine should be used to focus efforts to successfully transform today's military force.

If transformation is a term fraught with implications, then the term doctrine is even more so. Some services regard doctrine as "stultified written rules no one reads"[6], others view it as "the fundamental principles by which military forces guide their actions in support of national objectives."[7]. In practical usage, doctrine forms an intermediate value on a continuum where tactics, techniques, and procedures (TTP), the rules for small/individual unit operations, bound one end and strategy, the rules of military actions as a part of overall national policy, the other. This paper uses the term doctrine in its largest sense; those generally accepted rules, whether written or unwritten, that define best operational practice. Doctrine is explicitly inclusive of operational concepts/concepts for operations (CONOPS). It implicitly includes doctrine which technology must advance to enable and doctrine that is developed in reaction to new technology.

The idea that technological advances and changes in doctrine form a duality is not new. Systems have long been described as either technology push (a new technology/system without pre-existing requirements; e.g. the revolving turret on the Monitor, the AWACS

aircraft) or technology pull (incremental advances to a technology/system based on requirements; e.g. monoplane vice biplane aircraft in WW II). Regardless of "push" or "pull", doctrine has consistently played a large role in the success of new military systems/technologies.

The fundamental doctrinal issue facing interwar navies was how to strike and destroy their opposition before they too could be destroyed. Immediately following WW I the primary naval weapons were large guns on battleships and cruisers; naval aviation had its roots in attempts to improve gunfire accuracy. Aircraft were to fly from battleships and cruisers, spot the shell impacts and radio the results back to the ship so that fires could be adjusted[8]. Gun technology was advancing throughout the interwar years and navies increasingly used larger (longer range) guns, culminating in the 18.1-inch guns on the Japanese battleships Yamato and Musashi, the largest battleships and operational naval guns ever built[9].

However, rapidly increasing aircraft range pushed the aircraft from a role of spotter for long-range battleship and cruiser fires to a system capable of striking beyond the range of even the largest of guns. As aircraft performance improved experimentation began on using aircraft as offensive weapons in their own right. Naval aircraft themselves could be a source of fire on the enemy. During WW I Great Britain developed operational aircraft carriers and began the construction of the first true aircraft carrier, HMS Argus[10].

The mere existence of aircraft carriers at the end of WW I did not preordain this as the obvious destiny of naval aviation. There were multiple options in addition to carrier-based aircraft. These included long-range land based patrol aircraft, large seaplanes, aircraft

launched from battleships and cruisers with various recovery options, and rigid and non-rigid airships.

Airships eventually fell by the wayside due at least in part to highly publicized crashes such as that of the Akron[11], as well as their slow speed and poor weather tolerance. Aircraft launched from battleships and cruisers were retained but assumed niche roles of spotting for gunfire and scouting. The limited launch weight and recovery problems proved too great for other missions to be assumed. Large seaplanes and land based patrol aircraft were retained by most nations. They offered advantages of longer range and greater payload due to the larger multiengine designs possible from their basing on established land or sheltered water facilities. The trade-off was that with their large size came a relative lack of speed and maneuverability. There were also limits to the range/payload trade space that left a gap in capability over large open ocean areas away from land mass. It was this gap that aircraft carrier and its embarked aircraft were to fill most clearly[12].

Coupled with the issue of outranging an adversary was the issue of pulsed power. The problem was how to generate a mass of fire sufficient to achieve a decisive impact. Naval gunfire had addressed this problem for years through the use of larger guns, which in addition to their longer range also fired a heavier shell. When multiple guns were fired simultaneously from one or more ships a potentially decisive quantity of fire could be delivered. The measure of effectiveness was to hit the target and achieve damage to some key part of the adversary vessel (damage engines, flood compartments, destroy adversary fire control, …). Note that much of this remained fairly close to the TTPs of sailing broadsides. The problem that faced the aviation advocates was how to create a similar quality of fire

from a system as limited as the interwar aircraft, especially when launched from an aircraft carrier.

One solution was to use the aircraft to extend the range of another naval fire mechanism, the torpedo. This however was not without its challenges. Torpedoes were heavy and relatively susceptible to damage when launched from an aircraft. Both of these problems posed technical and doctrinal issues for naval aviation and carrier employment in particular[13]. Japan's response to this issue combined outranging and pulsed power (see below). She initially tasked this mission to long range, land based aircraft (G3M) that were to *incrementally* wear down an opponent prior a decisive engagement. It was these aircraft that sank the Prince of Wales and Repulse in 1941.[14] Successive work by multiple nations (including Italy) were to devise the tactics, including tactics for harbor/shallow water attacks for truly operational aircraft carrier based aircraft which entered production just prior to WW II[15,16].

Arial bombardment likewise posed challenges. The celebrated sinking of the captured German battleship Ostfriesland[17], as well as the United States Navy's own tests on the old battleship Indiana[18] showed the potential for success. However, bombing a moving ship from an aircraft was to pose as difficult a technical and doctrinal question as that of employing the torpedo. Here the solution was to largely abandon level bombing. Instead, the navies adapted a technique developed for land based attack aircraft, dive-bombing. Not only was this more accurate (70% hits vs. 7%), it also thwarted most anti-aircraft techniques in place at the beginning of WW II.[19] This solution was so effective that both the Japanese variant (D3A) and United Stated Variant (SBD) were to sink more of an adversaries warships than any other aircraft[20,21].

If the previous paragraphs describe the question of power, there was also the challenge of pulsing the power, or creating the equivalent of a broadside. Quite simply, this was a problem of how many aircraft could an aircraft carrier (or a force of multiple aircraft carriers) launch at once, how could those aircraft arrive over a long distance target together, and then be safely landed upon their return to the aircraft carrier(s).

There were multiple approaches to addressing this issue; larger aircraft carriers to carry more aircraft that could then be launched in raids of more aircraft, more aircraft on "standard" sized aircraft carriers with tighter packing and revised operational doctrine and operations, and fleets of multiple aircraft carriers. Each option had its relative advantages. Larger ships had better damage resistance to attack due to armor and overall volume but multiple smaller ships could get more aircraft in the air faster.[22] Having more ships was obviously desirable but not achievable within the fiscal and treaty constraints of the interwar years. The studies and debates over this question forced review of how to fight fleets of carriers, of varying fleet size and aircraft carrier compositions, an area of study that was still incomplete as WW II began[23].

From the doctrinal resolution of the two issues of outranging and pulsed power, as evidenced in each nations fleet and academic/staff exercises, emerged a proposition that the aircraft carrier and its aircraft would become the preeminent fleet weapon system, vice the battleship and its guns. This paradigm change from aircraft as the supporting system to the primary system resulted in numerous studies by all the navies, and vigorous debate over fleet composition. These debates were unsettled until actual events in WW II forced the answer, the preeminence of the aircraft carrier and its aircraft, upon the fleets of all three nations[24].

Nations developing naval aviation in the interwar years faced daunting external challenges that shaped their answers to the outranging and pulsed power issues. Technological developments were occurring at a rapid pace, particularly in the core component of naval aviation and the aircraft carrier system, the airplane itself. Budgetary and industrial limits forced hard choices between fielding systems (ships and aircraft) with available technologies or continuing to develop technologies in hopes of obtaining greater performance, yet still having sufficient systems operational in time for conflict. Arms control treaties both limited development and presented opportunities to each of the nations.

Aircraft technologies matured at an amazing pace in the interwar years. Advances in engine horsepower coupled with aerodynamics advances resulted in short effective operational lives for each successive wave of designs. The Japanese experience with fighter types provides one vignette. When first introduced the Claude (A5M) was a model of performance and capability. Its sleek monoplane design outclassed earlier bi-plane types. However, within five years it too was deemed obsolete in the light of combat experience in China. Its obsolescence forced the development of the Zero (A6M)[25].

Each nation's own aircraft technology base developed at a different pace and made slightly different trades in design points and operational capabilities. As example, the Japanese tended to stress speed and agility[26] while the Americans tended to accept limits on these capabilities to obtain greater combat firepower and self-protection from more rugged designs and self-sealing gas tanks. Thus, each nation entered WW II with capable but highly different fighter aircraft in the forms of the Zero and Wildcat[27]. For each of the nations, as aircraft changed, so did their relationship with the aircraft carrier. Increasing capabilities in speed, range, and bomb load forced reexamination of carrier design and operations.

The key technology advance in aircraft was the increase in engine performance. Higher performance engines enabled improvements in speed, range, and bomb load. These improvements did not come without an impact on aircraft carrier design and operations. Higher overall speed also meant higher landing speeds. This forced each nation to develop aircraft arresting technology and a doctrine to launch, service, and land aircraft that maximized combat power from the carrier.

In general, higher speed aircraft forced larger carrier design, and ventilated (open) hangers (in which aircraft engines could be warmed prior to operation on the flight deck). Japan and the United States took this design path. Great Britain opted for relatively smaller carriers with enclosed hangers. Because they primarily envisioned aircraft carriers operating in close proximity to land based aircraft, as in the Mediterranean Sea, their carrier designs had more deck armor, and aircraft were housed in the below deck hanger to protect them from enemy attack while they were being serviced. Therefore, their naval aircraft designs that did not stress achieving the same performance as land based aircraft of the same design era. Correspondingly, at the start of WW II both the United States and Japan had high performance all monoplane carrier types; British capability was exemplified in the slow biplane Swordfish type. “During the war, the British Fleet Air Arm seemed to survive and thrive mainly because it adopted U.S. naval aircraft to replace its apparently inferior British-built types.”[28].

Just as the nations developing aircraft carriers were subject to the rapid advance of aviation technology, these nations also experienced force size limits, whether imposed through limits in overall industrial capacity, national economic limits, or some combination. Great Britain to focused its post WW I defense efforts on maintaining its empire. All

military forces were cut and those that remained were sized to emphasize economy. The United States similarly downsized its forces. The oceans were to serve as the defenses; large capital ships, battleships and cruisers, correspondingly received the bulk of defense funding. Japan pursued an expansionist policy throughout Asia and the Pacific but her economy could only produce so much and the Army's demands for its campaign in China took up much of that capacity. Also, her shipyards could only produce a limited number of large capital ships regardless of type. Japan faced a similar problem in aircraft production compared to the United States.[29] The effect in all cases, either by choice or necessity, was a limited pool of resources to expend on new systems such as the aircraft carrier and its associated systems such as aircraft. Thus, each production carrier and generation of aircraft was a singular investment of national resources as well as a gamble on overall design and operational effectiveness for years to come.

Treaties interrelated to both technology and finances. The London and Washington Naval Treaties limited the number and size of vessels in each nation's navy. The treaties were designed to promote peace by freezing a relative level of force capability between the five major naval powers. The treaties also provided windows of opportunity and choice as each nation had to decide how to allocate the allowed tonnage within ship types. Treaty compliance required a combination of scrapping vessels under construction, converting vessels under construction to another type (e.g. cruiser hulls finished as aircraft carriers), and/or scrapping existing vessels. All three nations chose to utilize large hulls originally designed for cruisers for aircraft carriers; the United States Lexington and Saratoga[30] and Japanese Akagi and Kaga[31] and Great Britain's Glorious and Courageous[32] are examples of vessels that saw service in WW II that were originally designed as another type.

Use of historical case studies to determine lessons learned for future approaches suffers from an inherent flaw if the past environment does not closely match that faced by current decision makers. The historical environment shows great similarity today's environment.

Just as the technologies of the aircraft carrier were rapidly evolving so are technologies of todays military. All computer-based systems are subject to the seeming inevitability of Moore's Law[33]; today's front line processor is technically obsolete in approximately four years. Software suffers from a similar fate. FORTRAN and COBOL were the common computer language of the 70's; both were largely obsolete by the time most user organizations recognized the need to prepare old software for the Year 2000 transition. Firmware and embedded processors face similar perils, as parts used ten years ago are no longer replaceable on a one for one basis; on-chip integration is increasingly the norm in processor technology. In general, tasks once reserved for stand alone mainframes or supercomputers now are well within the capability of much smaller computers. Sensor technology (e.g. radars, infrared seekers) faces the same obsolescence trends. Operational vehicles (e.g. aircraft/ships) are increasingly becoming platforms for their software/electronics subsystems[34].

Budgetary constraints are as real now as they were in the interwar years. Just as the nations developing the aircraft carrier faced excruciating choices concerning numbers and types of systems so does today's Department of Defense. Even after the additions to the defense budget after the 9/11 terrorist attacks, the Department of Defense is unable to fully fund both existing legacy systems and transformational systems. Increasingly small platform production runs (the F-22 is now proposed to be 180 vice its previous low of 295, and a

requirement of 339[35]) and limited number of types in production (the F-22 and JSF productions are not intended to overlap due to budgetary reasons[36]) are forcing a contraction of the contractor base and the Government is being faced with funding research and development (R&D) work to supplement production efforts, just as the Navy Board supplemented civilian aircraft R&D.

Finally, treaties and other legal constraints limit force choices. It is true that nations may withdraw from treaties (such as the recent United States withdrawal from the Anti-Ballistic Missile treaty) but even treaties that have not become formal law have limited United States force options. At times the various strategic arms treaties between the United States and the Soviet Union/Russia have lacked formal approval by one or both of the parties, yet each nation's defense establishments have followed the treaty protocols. Finally, de facto limitations, such as the limits on use of crowd control agents in military situations, (which require Presidential approval), as compared to their use by law enforcement forces (unlimited use) is but one example of these limits faced by those developing transformational military systems.

It is thus seen that today's challenges are not dissimilar to those faced by the developers of the aircraft carrier. Common lessons from those developers should then also be applicable to today's efforts to maximize likelihood of achieving the desired transformational systems.

Common to the lessons learned from each nation is the critical role of doctrine, beyond the role of technological developments. Common to successful aircraft carrier development, and lacking in less successful aircraft carrier development, was a doctrinal focus on what the system could achieve. A counterargument could be made that the

technology (the airplane) was the real focus, and that the doctrine was developed to justify having the technology in the inventory. This simply isn't true. The doctrinal questions of outranging and pulsed power were the focus of all the navies. There were serious, even heated, arguments over how best to solve those issues (e.g. battleship vs. aircraft), but the doctrinal issues came first. This is similar to land based strategic bombing. The theories/doctrines (e.g. Douhet/Trenchard and bombing's effects on cities and populations) were in place and then drove development of technologies and systems that could enable those doctrines in practice. The doctrinal lead occurred in aircraft carrier development down to such tactical technologies as arresting gear. The practical developments fostered by Reeves and Moffet were driven by doctrinal drive of generating a pulse of power and getting that power to a target and back (e.g. Reeves and the larger embarked aircraft, Moffet and carrier aircraft with performance similar land aircraft).

Having justified the central thesis, doctrine as the center of gravity for transformation, it will now be used to demonstrate how it may be used to shape today's efforts. The historical lessons learned from each nation are presented as a common set of lessons learned, paired with specific recommendations on how doctrine should be used to forge transformation today.

a. Lesson: Academic war games were fully integrated with operational demonstrations. The schoolhouse and the real world were not disjoint organizations. Rather, they served to jointly develop theories of what was possible and then test those theories to see if they were achievable. Notably, this flow worked in both directions. Some ideas were resident in the fleet but could only be tested in academia (e.g. use of large numbers of aircraft carriers to achieve maximum pulsed power) and other ideas originated in academic settings

and then were demonstrated in fleet practice (e.g. use of aircraft carriers as strike platforms as demonstrated in the raid on the Panama Canal).

Recommendation: Link modeling and simulation to Fleet Exercises. Model/simulation events and players would fill roles alongside fleet exercises and operators. As example, test employment of network centric warfare theories would employ real world operational exercises linked with academic/analytic network C2 exercises.

b. Lesson: Academic institutions were actively linked with the technological development bureaucracies. Academic studies pointed out what system attributes would be most profitable and deserving of development funding support. The Japanese Navy's aircraft designs consistently matched their doctrine; the Zero and other carrier-based aircraft all had long ranges matching their academically and staff developed doctrine of outranging an adversary to achieve a decisive first strike.

Recommendation: Enhance linkage between academic institutions and development organizations. Currently, academics are tasked with "system after next" concept studies and developers acquire and field the "current" designs. This hard break precludes incremental changes and perpetuates a fixed choice environment (you either get something futuristic or you get more of today's systems - no middle ground).

c. Lesson: Development goals were stated in operational effects, rather than technical specifications. Measures of Effectiveness (MOEs) should not and must not be confused or confounded with technical performance. The Japanese gave up higher speeds for their aircraft, such as the Zero, when it was revealed that this would sacrifice other desired operational capabilities such as maneuverability. Even when the Japanese had to give up on higher speeds the Zero, it was still faster than all of the United States aircraft it faced until

halfway through the war. Developing a sound MOE does not require a detailed technical specification. The current statement of need process used to establish operational requirements is largely undervalued when assessing system effectiveness. A collective focus on quantifiable metrics has created an intellectual block on more subjective metrics. MOEs, particularly as evaluated in operational testing, must not be confounded with technical performance satisfaction. As example, "functional ability to deliver a strike" is a more useful operational metric than the more specific and measurable term of "radar cross section".

Recommendation: Clearly delineate between development technical specifications used to manage development contracts and operational capabilities used to determine operational effectiveness or suitability. As example, the development metrics for network centric warfare would be bandwidth and processing throughput but the operational metrics would be improved fire support (target acquisition to target kill) or decreased decision time for human operators. Note that many of these MOEs would reemphasize traditional principles of war. The offensive component of information warfare (cyber war) is particularly suitable for definition in these terms. An appropriate MOE would be to incapacitate an adversary's computer network. A detailed technical specification on how the network is incapacitated may inhibit alternative means of achieving that operational effect.

d. Lesson: Transformational systems (including their human component) were part of the fielded force, and used in real world events. The experience both the United States and the Japanese obtained from this practice lead to greater acceptance of the new systems by the existing force. The experience also pointed out areas where even systems with operational limitations (e.g. the Langley, the Claude) could still achieve significant operational results, when used within those limits. Recent successes, such as the Predator

reinforce this point. The Predator has numerous limitations in terms of weather, command and control functionality, etc. yet it fills a unique need for operational commanders. These commanders have resoundingly demonstrated they are willing to live with an imperfect system specifically because of its unique capabilities.

Recommendation: Fully integrate potential capabilities and operational specialties within the service. Examples of new specialties are a proposed "info corps".[37] Similarly, we should loose our resistance to deploying transformational systems that may not be fully operational. One positive example is the employment of the Joint Starts aircraft and radar in Desert Storm and then in other theaters. While the system has not yet received a formal Initial Operational Capability (IOC) certification, it has provided utility to some operational commanders while the developers have obtained a better understanding of real world performance and how the system should be improved to increase operational utility.

e. Lesson: Operational experimentation was an important means of developing transformational systems. Transformation implies in its definition something new. It is by definition not an incremental evolutionary modification to existing practices. If we truly want new answers we have to allot resources; time, people, and capital, to ask new questions. Great Britain stifled their aircraft carrier innovations after WW I intellectually and materially. Great Britain self constrained their aircraft carrier development by force fitting the ship, the airplane, and the doctrine into an answer that was bureaucratically efficient. They all matched each other: shorter-range operations, shorter-range aircraft, armored decks and hulls, integration with the fleet's guns. However, this solution proved to be less effective than either the Japanese or United States solutions to the same operational issues. Experimentation is vitally important for transformational systems -- systems for which there

is no real experience and which may still be in the "It's a neat toy but what do I do with it" stage. The simulated raid on the Panama Canal in Fleet Problem IX is an almost perfect example. Admiral Reeves used the Saratoga's strike force separately from the battleships and achieved such success in this unscripted event that "after Fleet Problem IX, carriers were accepted fleet units."[38] It is worth noting that this was not Reeve's original plan, rather it resulted from logistical events that occurred within the exercise. The raid's unconventional use of an aircraft carrier so closely mirror's a classic cruiser raid that it reinforces the thought that doctrinal breakthroughs do not occur in an intellectual vacuum. Rather, they are a result of inspired response to environment. Ask a different question/look at a problem in a different light and a new solution appears.

Recommendation: Integrate experimentation with proficiency exercises held at test ranges. An example would be the OPFOR at the National Training Center who utilize systems and tactics representative of prospective adversaries to test United States tactics and doctrine. This force on force capability provides an opportunity to test alternative force mixes in conjunction with a "control" (either the OPFOR or the US force) to determine what aspects of each paradigm provide the best overall operational effectiveness.

This paper questioned a basic tendency in our current quest for transformation, a tendency that puts technologies and weapon systems first and only peripherally addresses doctrinal issues. Aircraft carrier development in the interwar years closely parallels today's challenges; challenges of rapidly evolving technologies, constrained fiscal and industrial capacity, and legal limits imposed by treaties and other conventions. Three nations actively pursued the aircraft carrier as a weapon system in the interwar years, all three eventually focused on the same two operational issues, outranging and pulsed power. Two of these

nations, Japan and the United States, were able to develop successful solutions to these issues within their respective challenges. The clash of these solutions is what made possible the epic naval battles in the Pacific Ocean in WW II. Great Britain also developed a solution to these challenges, and was able to achieve some notable successes in WW II, notably the raid on the Italian fleet at Taranto and the damaging the Bismarck that led to her eventual sinking. Still, this solution was lacking in many aspects and Great Britain, which sent delegations to both the Untied States and Japan to lead those nations in their initial aircraft carrier development, found itself having to learn from their systems at the war's end.

The review of how these nations managed their development validates the central thesis of this paper. The more successful developments used doctrine to leverage and guide technology. Doctrine, the theory of how to apply a system/technology to achieve the desired operational effect, must regain a primacy if forces are to achieve successful transformations. Common themes were found in each nation that led to a set of guiding principles for today's transformational forces: war games integrated with operational demonstrations, academic institutions linked with development bureaucracies, development goals stated relative to operational effects, transformational systems (including their human component) a fully integrated part of the fielded force, and dedication of resources to "play time" innovation.

A final note: doctrine itself must become forward looking and transformational. It must be more than a bureaucratic exercise codifying unwritten practices. It must be forward looking and guide not just how we fight today, but how we want to fight tomorrow. Transformational doctrine is not the purview of a dedicated, isolated bureaucracy; it is the engine of entire fielded force with linkage and interplay from academic study, operational exercises and experimentation, and technical innovation.

NOTES

Note to the reader: Two references on interwar carrier aviation development are simply authoritative, to the point that they reference each other as such; Hone et al (United States and Great Britain) and Evans and Peattie (Japan). The Van Tol Joint Forces Quarterly articles are simply derivatives of the Hone et al manuscript. Much of this paper was derived from their work and it is why the majority of the references are to these authors. (Peattie has recently published a new manuscript on Japanese naval aviation that is included in the bibliography. It was unavailable at the time this paper was prepared to be used for endnotes or specific references.)

[1] There is no single source to substantiate this assertion. Two cases demonstrate the point. Precision weapons are now the standard, achieving accuracies measured in single feet vice Vietnam era munitions that were measured in the tens of feet. Similarly, even in the Vietnam era flight software was carried in special pods or mission racks. Now even transport aircraft (e.g. C-17) have thousands of lines of flight code just to fly the aircraft. Fire control centers in naval vessels and army vehicles (e.g. Abrams tanks) share this same phenomenon.

[2] Jaffe, Greg, "Special Report: Spending For Defense: New and Improved?", Wall Street Journal, March 28, 2002

[3] Ibid Jaffe

[4] Ibid Jaffe

[5] Clausewitz, Carl von (ed. Howard, Michael Eliot, and Paret, Peter), On War, Princeton University Press, Princeton, N.J., 1989, p. 358 – This timeless quote reads in part "… the hub of all power and movement, on which everything depends. That is the point against which all our energies should be directed."

[6] FitSimonds, James R., personal email note 9 April 2002

[7] Air Force Doctrine Document 1-1, AF Doctrine Center, Maxwell AFB, AL, September 1997, p. 1

[8] Evans, David C., Mark R. Peattie, Kaigun: Strategy, Tactics, and Technology in the Imperial Japanese Navy, Annapolis, MD, Naval Institute Press, 1997, pg 262, 295, 298

[9] Ibid Evans and Peattie, pg 295, 372

[10] Hone, Thomas C., Norman Friedman, and Mark D. Mandeles, American and British Aircraft Carrier Development, 1919-1941, Annapolis, MD, Naval Institute Press, 1999, pg 87

[11] Ibid Hone et al, pg. 73

[12] This paragraph summarizes numerous sections in both Hone et al and Evans and Peattie

[13] Ibid Evans and Peattie, pg 327, and Hone, pg. 63

[14] Ibid Hone et al, pg 111

[15] Ibid Hone et al, pg 112

[16] Ibid Evans and Peattie, pg 307

[17] Ibid Hone et al, pg. 29

[18] Ibid Hone et al, pg. 27

[19] Ibid Hone et al, pg 163

[20] Ibid Evans and Peattie, pg 307

[21] Ibid Hone et al, pg 163

[22] Ibid Hone et al, pg. 57

[23] Ibid Evans and Peattie, pg 347-349, and Hone, pg. 54-55

[24] Ibid Evans and Peattie, pg 590, Note 66. "By the late summer of 1942, in any event, the super-battleship strategy was dead, a victim not so much of the battleship's demise as of the carrier's rise as the prime element of naval power …"

[25] Ibid Evans and Peattie, pg 305-306

[26] Ibid Evans and Peattie, pg 307-312

[27] Ibid Hone et al, pg 141

[28] Ibid Hone et al, pg 87-88

[29] Ibid Evans and Peattie, pg. 358

[30] Ibid Hone et al, pg 57

[31] Ibid Evans and Peattie, pg. 314

[32] Ibid Hone et al, pg. 91-92

[33] Alberts, David S., John Garskta, Fredrick P. Stein, <u>Network Centric Warfare: Developing and Leveraging Information Superiority</u>, National Defense University Press, Washington, DC, 1999
"In 1965 Gordon E. Moore, then R&D Director at Fairchild Semiconductor and presently Chairman Emeritus of Intel Corporation, observed that semiconductor manufacturers had been doubling the density of components per integrated circuit at regular intervals from 1959 to 1964. Furthermore, he asserted (based on three data points) that this trend was poised to continue for the foreseeable future (at least the next ten years). Upon reexamination by Moore in 1975, the regular interval turned out to be approximately 18 months. The net result is that for the past 45 years the performance of computer chips has doubled approximately every 18 months as a direct result of increasing component density. It is worth noting that the performance of dynamic Random Access memory (dram) chips has increased at a faster rate than computer chips."

"The limits of continued processing in increasing the density of semiconductor processing chips based on silicon technology are defined by physics. Scientists at Bell Laboratories recently identified (Nature, Volume 399, June 24, 1999, 758-761) that fundamental limits to chip density will be approached in 2012, when semiconductor gate sizes reach atomic limits."

What the last paragraph fails to address is means of increasing density/speed through alternate means some of which are already becoming standards, e.g. lower electric power on chips (from 5 V to 3.2V). Also, the atomic limit in question is only for one material, silicon, and other materials (e.g. GaAs) are still fertile grounds for improvement (the ubiquity of Si based chips has served to limit commercial use of alternative materials). Finally, the nano-device concept also offers potential for a new Moore's Law basis. Moore's Law has been declared dead before, with rumors of demise greatly exaggerated. For military purposes, the limits are far from broached.

[34] The B-52 is an instructive case. The basic airframes in use today were built in the late 1950'/early 1960's. It used to be news for the aircraft to have aircrew/pilots younger than the airframe. That situation is now so common no note is made of the phenomenon. Its avionics and weapons have been upgraded/modified multiple times over the years so the system went from a high altitude nuclear delivery aircraft to a low altitude penetrating nuclear delivery aircraft to a high altitude conventional "iron bomb" delivery aircraft to a stand-off cruise missile delivery aircraft to a precision munitions delivery aircraft. It is scheduled to remain in active service for years to come. Its longevity as a platform is even more remarkable for an era increasingly dominated by "stealth" doctrine, especially in the Air Force. The B-52 is so un-stealthy it serves as the reference standard for how much stealthier every other platform is!

[35] Bloomberg News, Air Force ordered to Weigh Plane Cuts, Washington Times, pg. C9, 1 May 2002

[36] Bloomberg News, Air Force ordered to Weigh Plane Cuts, Washington Times, pg. C9, 1 May 2002

[37] Network Centric Symposium, Naval War College, August 2001, personal notes, during FBE-I panel discussion

Fleet Battle Experiment India results noted that the need for an “info warrior”/”net-meister” to manage the information flow and network (citation at end). This is not a new observation. Early network centric platform prototypes were fielded with contractor support for this same reason. The inability to retain highly trained information technology enlisted personnel has been noted by all the services. If network centric warfare is implemented, the information staff will become such a key enabler they may become their own discipline. The military must find a means to harness this staff capability within the military force to ensure successful implementation of the networks. History provides multiple potential approaches, all of which have some degree of risk: 1) service within a service (a la the “black shoe/brown shoe” Navy). The danger here is that the cultural divide may become too great to hold (“tennis shoe/sandals” Navy) 2) inclusion followed by spin-off (a la the Army Air Corps). The danger here is the potential for a stunted doctrine (air power as airborne cavalry scouts). 3) service within a service (a la the Air Force’s burgeoning “Space Corps”). The danger with this alternative is the push to create a service when all that may be needed is just a specialty. 4) Warrant Officers (a la the Army’s tank and helicopter commanders). The danger with this alternative is a lack of inclusion within the greater professional “network”. The universal presence of risk in all these approaches argues for the services to implement more than one of these approaches in trial form, with the most successful being chosen at some later point for “joint” implementation.

[38] Ibid Hone et al, pg 49

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